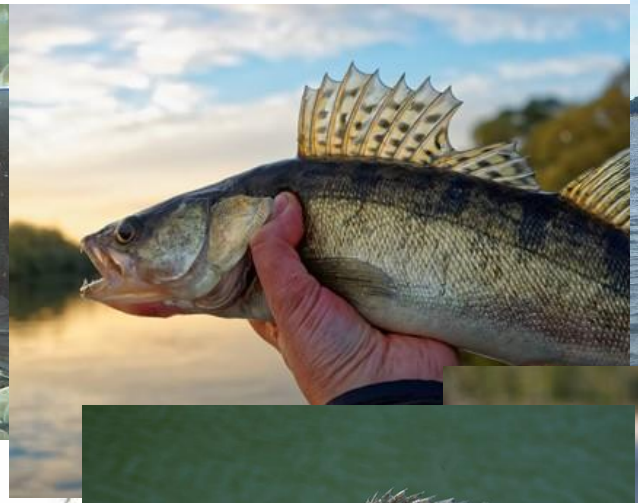
LimnoTech
Water Environment | Scientists Engineers

Revisions to Cadmium and Lead Aquatic Life Water Quality Criteria

Presentation to the
Water Protection Forum
Jefferson City, Missouri
December 11, 2018

Objective

- Establish criteria protective of aquatic life based on best available science

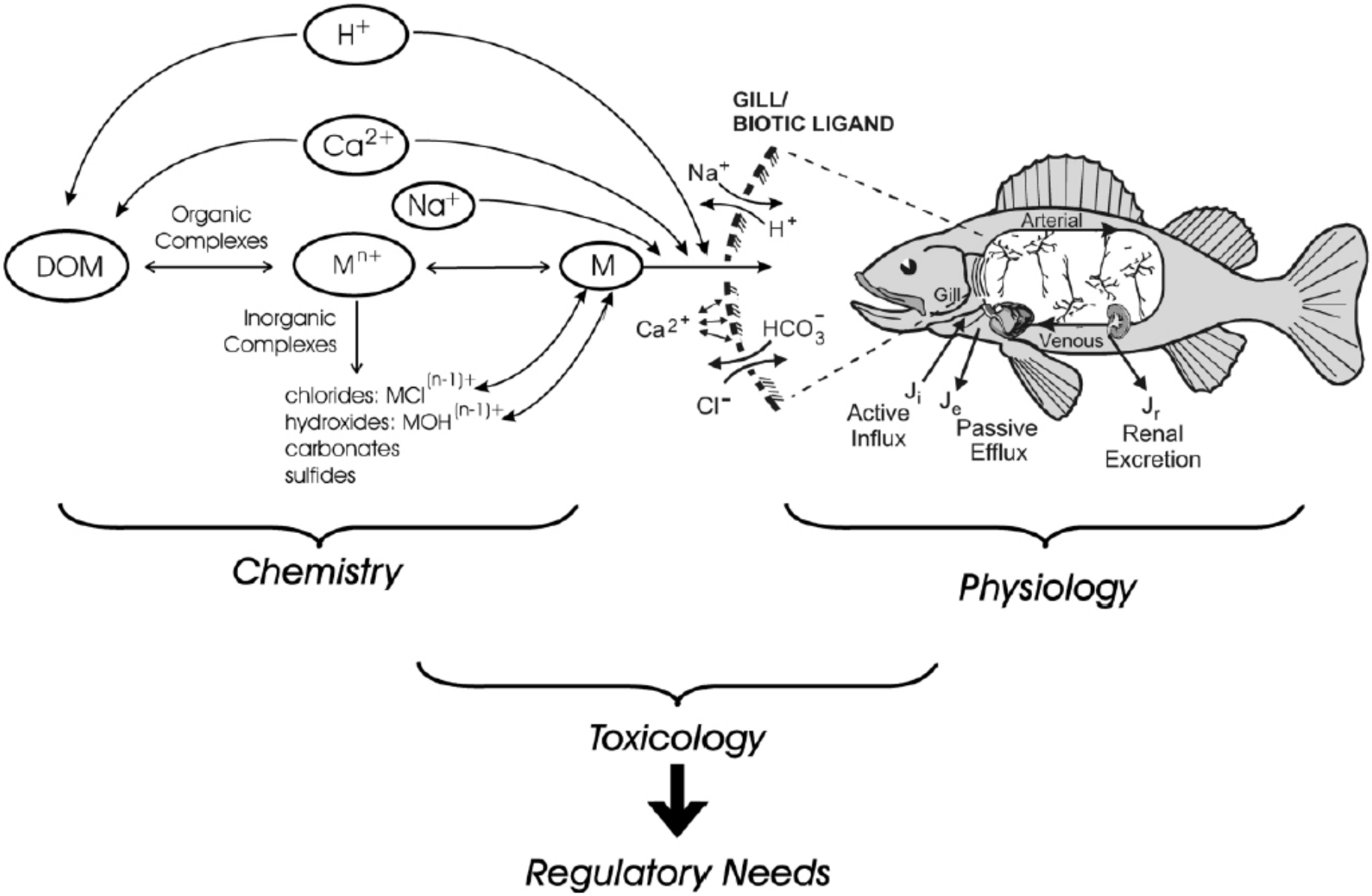


Basis for Aquatic Life Criteria

- Criteria are based on toxicity tests for a variety of species

Bioavailability of Metals

- Bioavailability of a metal is dependent upon what else is in the water
  - Metals may “bind” with organic matter or other ions, reducing bioavailability
  - Other ions may “compete” for places on a biotic ligand, such as a fish gill
- A Biotic Ligand Model (BLM) is a tool for predicting bioavailability of a metal


H+
Ca2+
Na+
DOM
Organic Complexes
Mn+
M
Inorganic Complexes
chlorides: MCl(n-1)+
hydroxides: MOH(n-1)+
carbonates
sulfides
GILL/
BIOTIC LIGAND
Na+
H+
Ca2+
HCO3−
Cl−
Arterial
Gill
Venous
Ji
Active Influx
Je
Passive Efflux
Jr
Renal Excretion
Chemistry
Physiology
Toxicology
Regulatory Needs

Existing Criteria

Table A2. Criteria for Aquatic Life Protection

POLLUTANT	CAS #			
METALS (µg/L) - Hardness Dependent				
Cadmium	7440439	Acute	=	$e^{(1.0166 * \ln(Hardness) - 3.062490)} * (1.136672 - (\ln(Hardness) * 0.041838))$
		Chronic	=	$e^{(0.7977 * \ln(Hardness) - 3.909)} * (1.101672 - (\ln(Hardness) * 0.041838))$
Lead	7439921	Acute	=	$e^{(1.273 * \ln(Hardness) - 1.460448)} * (1.46203 - (\ln(Hardness) * 0.145712))$
		Chronic	=	$e^{(1.273 * \ln(Hardness) - 4.704797)} * (1.46203 - (\ln(Hardness) * 0.145712))$

Existing metals criteria are hardness dependent

- Hardness is a measure of the calcium and magnesium ions present
- The higher the hardness, the more ions, the lower the bioavailability of the metal

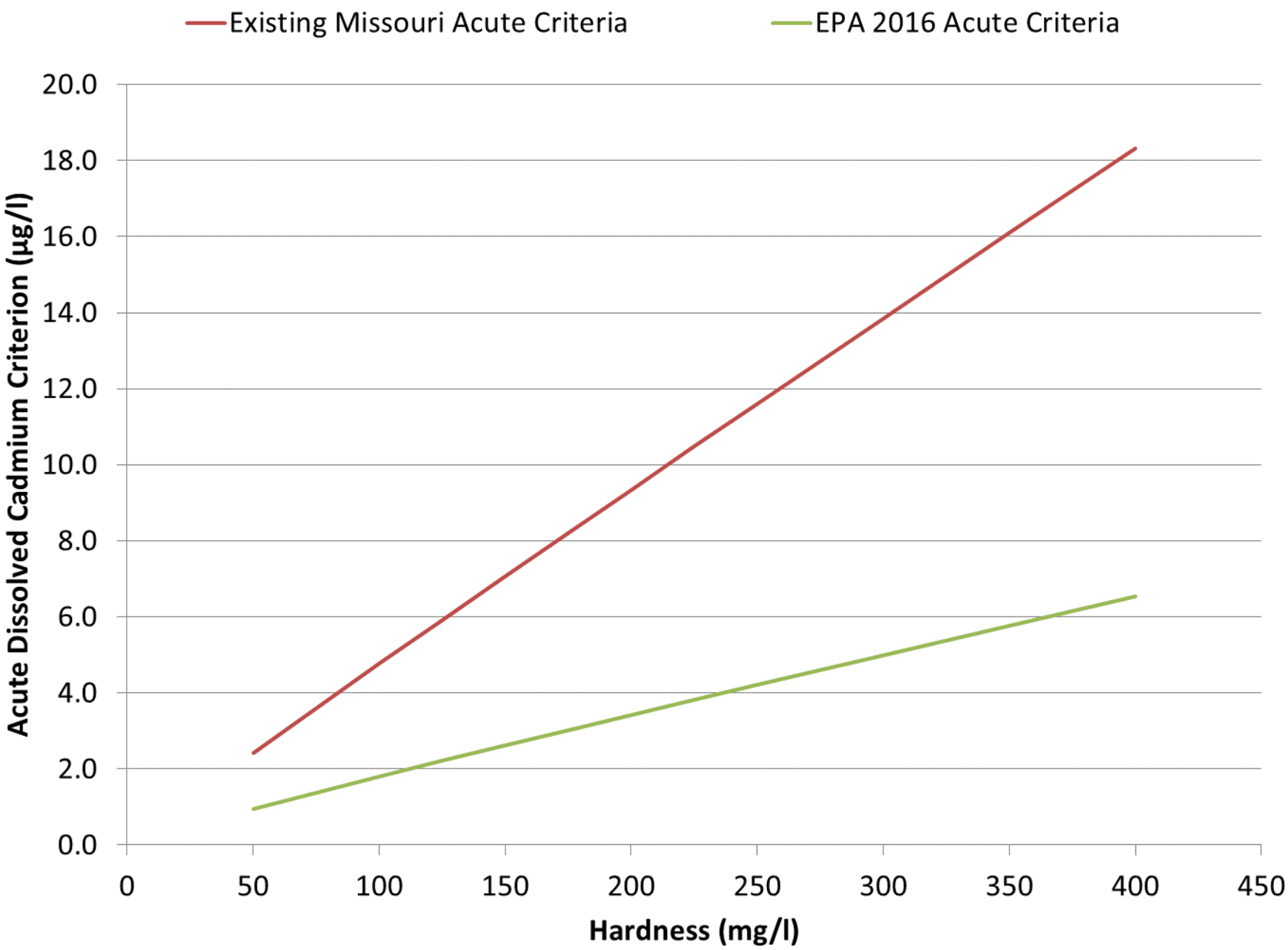
Basis for Existing Criteria

- Cadmium (Cd)
  - EPA updates in 1985, 1995, 2001 and 2016
    - Missouri's acute criteria are based on 2001 update
    - Missouri's chronic criteria are based on 2016 update
- Lead (Pb)
  - EPA update in 1984
    - Missouri's acute and chronic criteria are based on 1984 update

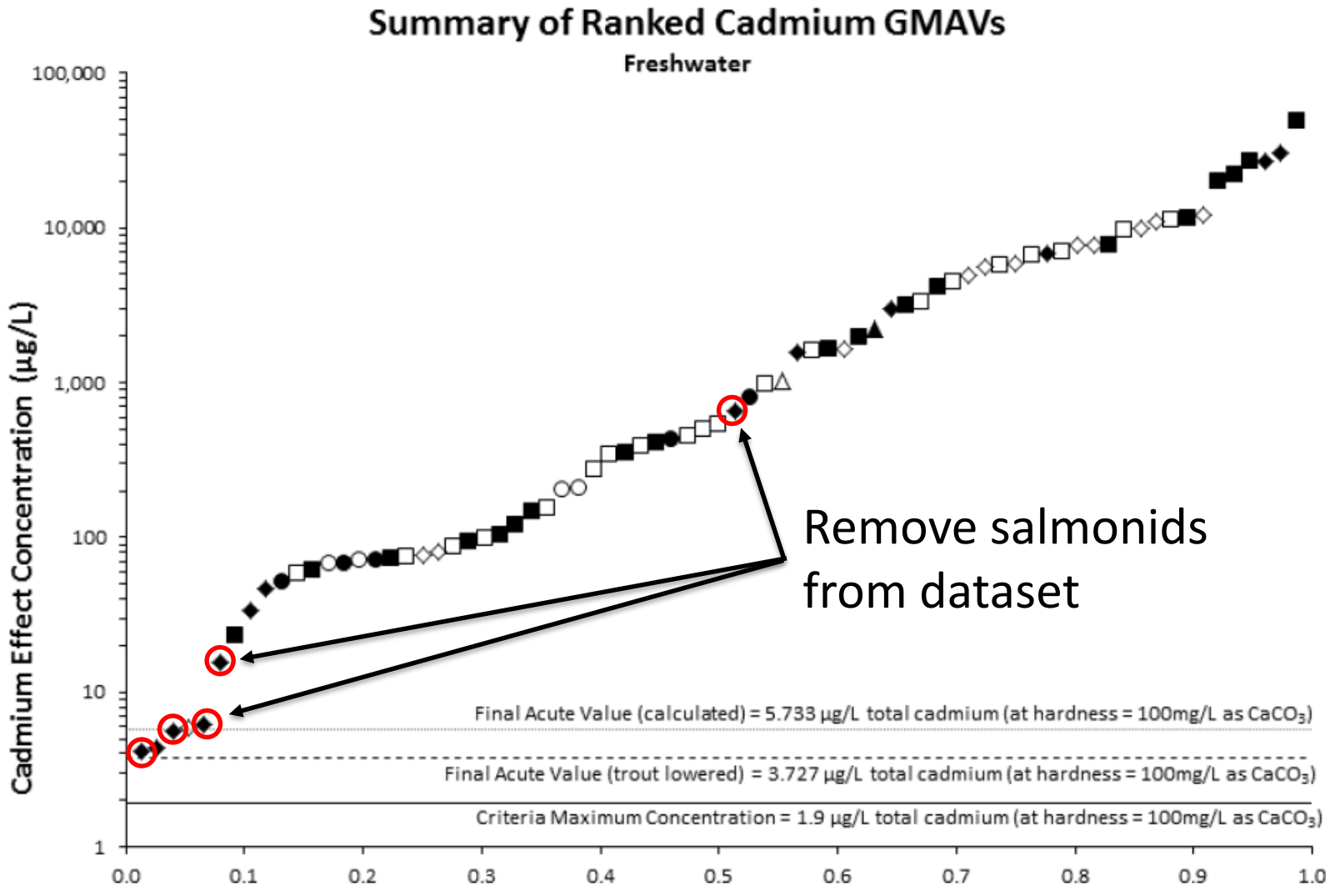
Acute Cadmium Criteria

Cadmium Criteria Overview

- Chronic criteria
  - Missouri adopted EPA 2016 criteria for all waters
    - We're good!
    - Expect EPA approval soon
- Acute criteria
  - EPA 2016 criteria more restrictive than existing Missouri criteria
    - Driven by protecting rainbow trout


Existing Missouri Acute Criteria
EPA 2016 Acute Criteria
Acute Dissolved Cadmium Criterion (µg/l)
20.0
18.0
16.0
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
0
50
100
150
200
250
300
350
400
450
Hardness (mg/l)

Recommend Recalculating for Cool and Warm-water Acute Cadmium Criteria



Source: EPA Aquatic Life Ambient Water Quality Criteria Cadmium - 2016

Cool and Warm-water Acute Criteria

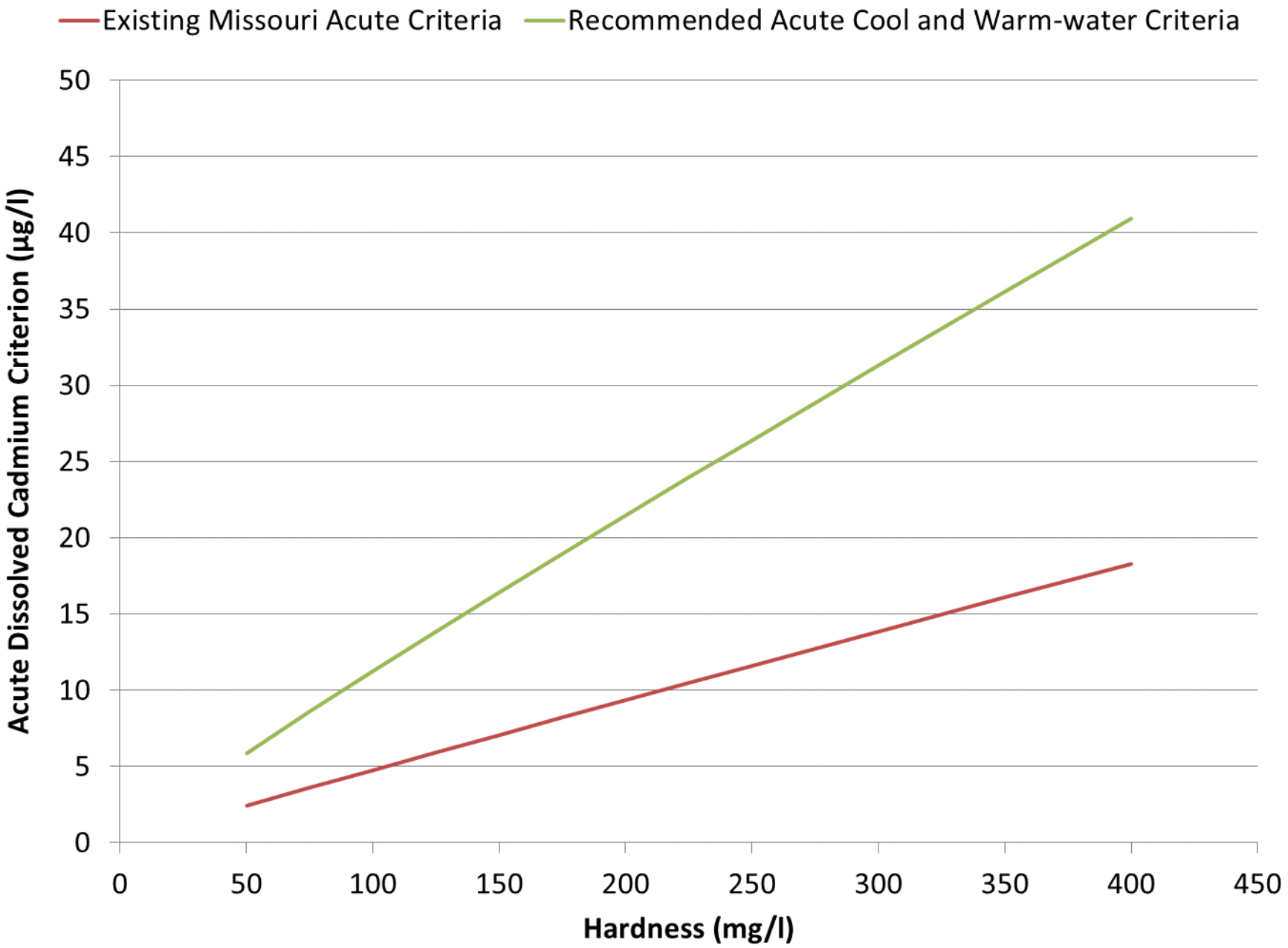
Genus	GMAV (µg/l) at 100 mg/L Hardness
Ptychocheilus (pikeminnow)	46.79
Acipenser (sturgeon)	33.78
Hyalella (amphipod)	23.00
Morone (striped bass)	5.931
Total number organisms	70
Final Acute Value (FAV)	23.8
Criterion Maximum Concentration (CMC)	11.9

Results in the following acute cool and warm-water criterion:

$e^{(0.9789 * \ln(\text{Hardness}) - 2.032)}$

With the appropriate translation to dissolved:

$* (1.136672 - (\ln(\text{Hardness}) * 0.041838))$


Existing Missouri Acute Criteria
Recommended Acute Cool and Warm-water Criteria
Acute Dissolved Cadmium Criterion (µg/l)
0
5
10
15
20
25
30
35
40
45
50
0
50
100
150
200
250
300
350
400
450
Hardness (mg/l)

Lead Criteria

Lead Criteria Overview

- EPA criteria developed in 1984
  - Data through 1984
  - Acute data for 10 species
  - Chronic data for 4 species
  - Hardness regression for 3 species
- Additional data available
  - ~36 species
  - Hardness regressions for ~7 species
  - Chronic data for ~10 species

Recommended Approach to Lead Criteria Revision

- Compile and review most recent data
- Follow EPA procedures to recalculate
- Consider latest Biotic Ligand Model developments
  - Accounts for bioavailability adjustments for not only hardness, but also pH and organic carbon
  - EPA Cooperative Research and Development Agreement (CRADA) underway
  - Current BLM tools predict criteria 3 to 5 times higher than existing criteria in higher hardness/higher organic carbon streams

The BLM-based acute 5th percentile is divided by two for direct comparison to USEPA's acute criterion.

Figure 2. Comparison of BLM-derived (a) acute and (b) chronic 5th percentile Pb concentrations to USEPA's current hardness-based Pb criteria for a representative set of water chemistries

https://www.ila-lead.org/UserFiles/File/Newsletter%20files/DeForest%20et%20al_%20-%20BLM-based%20Pb%20Criteria%20Poster%20-%20SETAC%202016.pdf

Path Forward

Request to Review Criteria

- More and better data exist to support cadmium and lead aquatic life criteria
- Existing criteria can result in impairments, TMDLs, and permit limits that may:
  - be more restrictive than needed
  - cause compliance issues
  - be costly to meet
- The triennial review process is intended to address such issues